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SOILS OF THE PURCHASE REGION OF KENTUCKY

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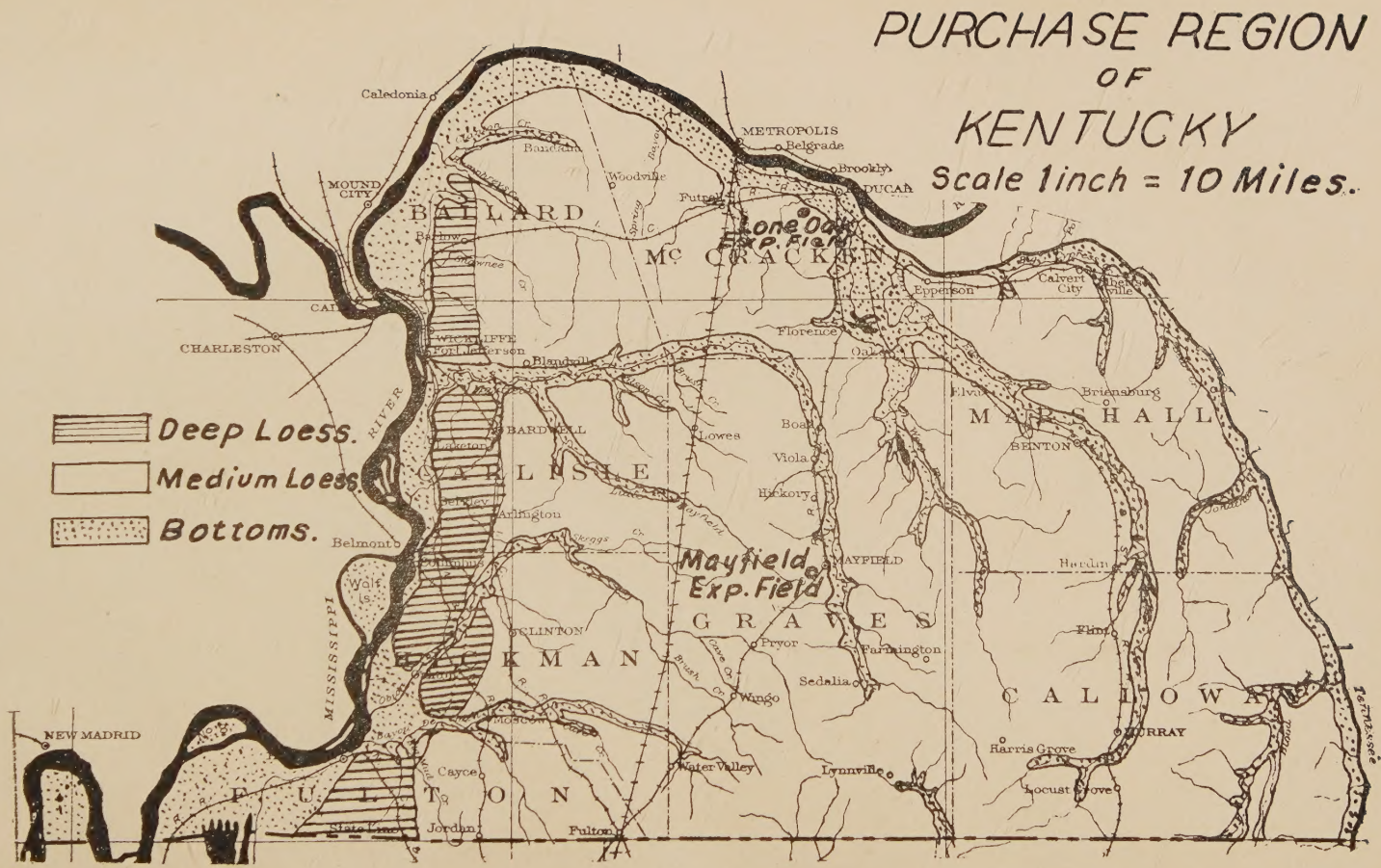
PURCHASE REGION
OF
KENTUCKY
Scale 1 inch = 10 Miles.
Deep Loess.
Medium Loess.
Bottoms.
Caledonia
METROPOLIS
Belgrade
Brooklyn
PADUCAH
MOUND CITY
BALLARD
Lone Oak Exp. Field
McCRACKEN
Calvert City
Paducah
CHARLESTON
Florence
Oak
Elvira
Briensburg
MARSHALL
BENTON
Lowes
Boaz
Viola
Hickory
CARLISLE
Arlington
Belmont
Mayfield Exp. Field
MAYFIELD
Hardin
GRAVES
Pryor
Farmington
Sedalia
Wingo
CALLOWAY
Flint
MURRAY
Harris Grove
Locust Grove
Water Valley
Lynnville
NEW MADRID
Cayce
Jordan
Fulton
MISSISSIPPI
RIVER

BULLETIN NO. 277

Soils of the Purchase Region of Kentucky

By S. D. AVERITT and S. C. JONES

INTRODUCTION

Since only rarely a farmer is interested in the soils of the state outside of his own vicinity, the plan has been adopted of making separate reports on soil areas corresponding to the principal geological divisions. It is hoped, in the absence of detailed county soil surveys, of which only sixteen have been made in Kentucky,* that this publication may meet the immediate needs of the farmers of the Purchase Region. Two or three of the counties already surveyed are situated in each of the principal geological areas, except the eastern coal field, and these counties are fairly representative of the sections in which they are located. The report of each survey is accompanied by a soil map on which the soil types described in the report are outlined. In any geological area, the types so described in the County survey may be extended, in a general way, to the entire area. In the case of of the Purchase Region (Quaternary Area), Bulletin No. 194, of this Station, "Soils of Graves County,"** maps and describes quite fully the main types of upland soils found in this section of the State. McCracken County has been surveyed by the U. S. Bureau of Soils..† The Kentucky Geological Survey, in 1888, published an elaborate report on the Purchase region, treating of the geology, soils and other economic features.‡

*Some of these surveys were made by the U. S. Bureau of Soils, some by the Bureau in collaboration with the Kentucky Agricultural Experiment Station, and some by the Station, partly in collaboration with the Kentucky Geological Survey. Most of the reports are out of print.

**Bulletin 194, Kentucky Agricultural Experiment Station, Soils of Graves County, by S. C. Jones. July, 1915. (Out of print.)

†Field Operations of the Bureau of Soils, 1905, U. S. Dept. of Agr., Washington, D. C.

‡Geological Survey of Kentucky, Volume F, Report on the Geological and Economic Features of the Jackson's Purchase Region. By R. H. Loughridge, Ph. D., 1888. Pp. 356, with 3 maps and several diagrams and photographic views.

SOILS

The Purchase Region is covered practically entirely by transported soils and, as originally classified by the United States Bureau of Soils, lies in the great Glacial and Loessal Soil Province. According to the Bureau, this is the most extensive of the thirteen soil provinces into which the United States has been divided. This soil province occupies mainly the north-central and northeastern portions of the United States and contains about 455 million acres. The soils of this province have been derived directly from glacial till and loess. Those formed from till are confined to that part of the country lying north of the southern limit of glacial action, but the loess soils occur also south of this line, especially along the Mississippi and Ohio Rivers. On the east side of the Mississippi River a strip of loessal soil extends entirely to the Gulf of Mexico. The Purchase Region of Kentucky lies in this strip.

This loessal material is supposed to have been carried down these and other streams during glacial times and to have been deposited subsequently over the uplands by prevailing southwest winds.

SOIL GROUPS

The soils of the Purchase Region may be divided, in a general way, into two classes, upland and bottom soils, with approximately one-fourth of the area bottom and three-fourths upland.

The upland soils may be divided into two general groups; deep loess, covering Mississippi bluffs, hills and plains, and medium loess, covering the hills and rolling or undulating uplands in the remainder of the Purchase Region.

The bottom soils may be divided into four general groups: First, large first bottoms along the Mississippi, Ohio and Tennessee Rivers; second, large second bottoms along the Ohio and Tennessee Rivers; third, small river bottoms, as along Clark's River and Mayfield Creek; and fourth, small bottoms along small creeks and branches.

When detailed soil surveys are made of the Purchase Region many soils types will be identified and mapped. In the mean-

time a general discussion of the soils under the foregoing classification, along with chemical analyses and the results obtained from the experiment fields at Mayfield and Lone Oak, should be of much practical value.

MEANING AND VALUE OF CHEMICAL ANALYSES OF SOILS AND CROPS

The chemical analysis of a soil serves somewhat the same purpose as a merchant's inventory of stock by showing how much of each of the important elements is present in the soil. From this knowledge a judgment may be formed as to what elements of plant food are present in sufficient quantity and what are not. This helps the farmer to proceed intelligently in the use of fertilizers, lime, legumes and manures for the improvement of his land. The chemical analysis of a soil will not answer the question of its adaptability to certain crops, except in a very general way or insofar as it shows whether or not the soil contains enough of the plant-food elements.

The tables of soil analyses in this report show the number of pounds of total nitrogen, total phosphorus, total potassium and of easily soluble phosphorus,* potassium and calcium, in both surface soil and subsoil, to the acre. The number of pounds of lime (calcium oxid, CaO) equivalent to the acidity found by analysis, is stated, also.

PLANT FOOD CONTAINED IN CROPS

Because the soil is the source of the mineral matter contained in crops and is the source of nitrogen for non-legume crops as well as part of the nitrogen for legumes, it is desirable to know the amounts of nitrogen, phosphorus and potassium contained in the crops grown in a region. In the following table the amounts of these three elements contained in common crops have been calculated for what may be considered fair yields. A more extensive table of such values and a detailed discussion

*The easily soluble phosphorus, potassium and calcium were obtained by shaking 75 gr. of water-free soil in 1500 cc n/10 HNO_3 several times during a period of one-half hour at room temperature, then filtering thru a dry filter and determining them in suitable aliquots of the filtrate.

of them with reference to soil analyses and maintenance of fertility will be found in Part II, Bulletin No. 228 of the Kentucky Agricultural Experiment Station.

TABLE 1.—Average Amounts of Nitrogen (N), Phosphorus (P) and Potassium (K) Contained in Some Crops.

Crop	N	P	K
	Pounds	Pounds	Pounds
Corn, 50 bu.	50	9	10
Stalks, 1½ tons	25	3	26
Total	75	12	36
Wheat, 25 bu.	36	6	6
Straw, 1¼ tons	12	2	23
Total	48	8	29
Oats, 40 bu.	26	5	6.5
Straw, 1 ton	13	3	21
Total	39	8	27.5
Tobacco, 1,000 lbs. of leaf (dark)	40	2.2	50
Stalks, 300 lbs.	10	.8	10
Total	50	3	60
Red clover, 1 ton	40	5	30
Cowpea, sweet clover or alfalfa hay, 1 ton	46	5	23
Timothy hay, 1 ton	24	3	24
Cotton, lint, 400 lbs.	1.2	0.2	1.6
Seed, 800 lbs.	25.2	4.4	7.6
Stalks, 1,600 lbs.	40.8	7.2	23.6
Total	67.2	11.8	32.8
Barnyard manure, 1 ton	10	3	8

To convert phosphorus to "phosphoric acid," P_2O_5, multiply by 2.3.
To convert potassium to "potash," K_2O, multiply by 1.2.

Comparison of the figures in table 1 with the soil analyses shows that far more easily soluble potassium was found in the surface soil to the acre than is contained in the given yields of

any of the crops, to say nothing of that in the subsoil, some of which certainly is available for plant growth. If we except tobacco, however, the phosphorus content of the crop usually approaches nearer to the amount of easily soluble phosphorus found to the acre in the surface soils. This fact is significant when it is noted that the potassum is chiefly in the stalks and straw and the phosphorus in the grain, the former being returned to the land as residues or in manure made by feeding them, whereas the grain often is sold and removed from the farm.

The nitrogen shown in the soil analyses is the total amount present. We do not know how much of this is available but from our knowledge of the nature of the organic matter of cultivated soils it is reasonable to assume that the proportion is relatively small. The amount of nitrogen needed by crops is much larger than that of phosphorus and since the cost of nitrogen in commercial fertilizers is so high as to be almost prohibitive except for crops of high acre value, maintenance of an adequate supply of nitrogen constitutes the main problem in the long cultivated soils in all sections of the State, and in the Purchase Region particularly, because these soils are generally low in nitrogen and it is lost rapidly thru leaching under the system of farming so largely practised in this section. It is probable that nitrogen may be the first limiting factor in the production of profitable crops in this region as it is well known that the soils respond markedly to manure which contains a relatively large amount of nitrogen as compared with the amount of phosphorus.

Study of table 1 in connection with the tabulated analyses of the soils, as suggested before, leads to the conclusion that any system of grain farming in which legumes are not given due place in the rotations will result very soon in soils too poor in nitrogen for profitable crops. In this connection it should be noted that one ton of clover, cowpeas, sweet clover or alfalfa returns to the soil, when plowed under, approximately as much nitrogen as four tons of barnyard manure.

When livestock is fed, about two-thirds of the nitrogen in the feed may be returned in the solid and liquid manure, under careful handling, and under the same conditions three-fourths

of the phosphorus and four-fifths or more of the potassium may be returned to the soil.

From the foregoing discussion three fundamental requirements for increasing and maintaining fertility in these soils stand out clearly.

(1) The supply of nitrogen must be conserved and increased by growing legumes, returning crop residues and manure properly rotating crops and using cover crops.

(2) Limestone or some other form of lime for correcting acidity and phosphatic fertilizers to supply phosphorus must be used.

(3) In the case of potassium, the problem is not serious, as it is largely a question of returning this element in crop residues and manures and liberation of the soil potash by increasing the organic matter content thru the decay of crop residues and manure. However, on such crops as cotton, tobacco and garden crops the use of potash may be profitable.

CHEMICAL STUDIES OF THE PRINCIPAL SOIL GROUPS

In selecting the samples for analysis, the intention has been to have them fairly representative of the soil groups being studied. Most of them were composite samples; that is, composed of several portions of soil taken from different places within a small area selected as being fairly representative of its group. The surface soils analyzed were taken to a depth of 6 inches which is about the depth to which they are plowed and consequently is the depth to which organic matter, limestone and fertilizers are incorporated in working the land. The feeding roots of most crops function mainly in the surface soil, hence the presence of a good supply of plant food in the surface soil is very important.

The subsoils were taken from 6 to 18 inches; that is, the samples analyzed represent the foot of soil next below the first 6 inches sampled as surface soil.

The dried soil to a depth of 7 inches over an acre is assumed to weigh 2,000,000 pounds. The subsoil over an acre from 7 to 20 inches, that is, the next 13 inches, is assumed to weigh 4,000,000 pounds. While these values do not hold exactly for

all soils their assumption involves no practical error and affords a convenient method of stating soil analyses for practical use. This method has been used in the following tables.

Besides the average of the analyses, the largest and the smallest findings for each substance are stated, in the columns headed "Maximum" and "Minimum." The average figures are the most important because the majority of the soils vary very little from these figures. The maximum and minimum serve mainly to show what extremes may be met with in each type. If the average is near the maximum, however, few samples are near the minimum, and if the average is near the minimum, few samples are near the maximum. If the average is about half way between the maximum and minimum, the number of samples above the average is about equal to the number below. With these facts in mind, the tables should prove of considerable value.

DEEP LOESS SOILS

The deep loess belt occupies the "bluffs" and the hills and rolling or undulating uplands adjacent to the Mississippi and Ohio River bottoms, extending in a strip from Humphrey's Creek, in Ballard County, thru Ballard, Carlisle, Hickman and Fulton Counties to the Tennessee State line. The steepest and highest bluffs occur along the Mississippi River at Columbus, in Hickman County. Here the deep loess bluffs range from 60 to 100 feet or more in height and stand as precipitous as rock ledges, while back in the plains are found rolling uplands.

The deep loess belt varies in width from some two miles immediately south of Humphrey's Creek, in Ballard County, to some six or eight miles in width adjacent to the Mississippi River bottom south of the town of Hickman, in Fulton County. The entire belt probably contains from 200 to 250 square miles.

The soil in the deep loess belt varies from light brown silt loam to yellow-brown fine sandy loam, of excellent tilth. It varies a great deal because of recent washing, the natural subsoil being exposed in some places. The natural surface soil ranges in thickness from 0 to 10 inches. The subsoil varies widely in its composition. In some areas it is a compact, yellow,

clayey silt, while in others it is made up of a mealy, silty, fine sand containing varying amounts of calcium corbonate. Some places where the roads are cut deep, sweet clover is found growing in the ditches and sometimes also in deep gullies in the fields. Alfalfa has been grown fairly successfully on some of the freshest land in the deep loess belt in the vicinity of Columbus, in Hickman County, and calcium carbonate was found in some of the samples of surface soil examined. Some very fine bluegrass pastures are found on some of the hills adjacent to the Mississippi River bottom. Burley tobacco of a very good quality is grown to a considerable extent in Ballard County. In Hickman and Fulton Counties, in recent years, cotton is being grown on this land. It has been considered very fine wheat land.

TABLE 2.—Plant Food Content of the Deep Loess Soils.—Pounds to the Acre, or in 2,000,000 Lbs. of Surface Soil (6 Samples).

	Average	Maximum	Minimum
Total nitrogen (N)	2,530	3,920	1,720
Total phosphorus (P)	1,667	2,140	920
Total potassium (K)	34,267	36,800	30,800
Phosphorus dissolved by weak acid (0.1n HNO_3), considered available	171	500	46
Potassium, same	365	594	216
Calcium, same	3,720	5,280	2,240
Acidity calculated as lime (CaO)	39	60	10

Pounds to the Acre, or in 4,000,000 Lbs. of Subsoil (One Sample).

	Average	Maximum	Minimum
Total nitrogen (N)	2,320		
Total phosphorus (P)	4,560		
Total potassium (K)	83,200		
Phosphorus dissolved by weak acid (0.1n HNO_3), considered available	184		
Potassium, same	496		
Calcium, same	7,920		
Acidity calculated as lime (CaO)	20		

Inspection of table 2 shows a considerable range in the proportions of easily soluble phosphorus, potassium and calcium in the surface soil; however, the proportion of easily soluble phosphorus is far above the average of the other upland soils. The content of easily soluble potassium is large. The supply of calcium is fair and very slight acidity is shown. Analyses of the subsoil doubtless would show as much variation as is shown in the surface soils. Judged by the chemical analyses, the soils of the deep loess are the best upland soils of the region.

It is quite probable that on much of this land legumes, especially alfalfa and sweet clover, would be benefited greatly by the application of limestone. In some cases phosphorus in addition to the limestone would be necessary for the best results.

The proportion of total potassium in the soil of the deep loess belt as, indeed, in all the soils of the Purchase Region, tho smaller in some than in others, is ample. It only needs to be conserved and liberated by the use of cover crops, rotation of crops, and returning crop residues and manure to the land, except, perhaps, for some special crops, as already indicated.

THE MEDIUM LOESS SOILS

The medium loess soils cover the entire upland in the Purchase Region, aside from the narrow deep loess belt adjacent to the Mississippi River bottoms in Ballard, Carlisle, Hickman and Fulton Counties.

On the basis of topography, the area of medium loess soils is made up of two general types, namely, the "yellow brown silt loam" (hilly) and the "yellow silt loam" (undulating). (See Kentucky Experiment Station Bulletin 194, Soils of Graves County.)

The yellow brown silt loam, or hilly type, is the most extensive and probably constitutes as much as 45 percent of the entire Purchase Region. It occupies the hilly or dissected sections and is found in extensive areas in all the counties. The hills in this area range from 30 feet to about 100 feet high, averaging perhaps not over fifty feet. Thruout the area is found a considerable quantity of rolling ridge land, perhaps twenty-five percent or more of the area, while many of the hillsides are gently sloping.

The yellow silt loam or undulating type is the next most extensive and probably covers 35 percent of the entire Purchase Region. This type varies from gently rolling to rather level lands that occupy the low uplands, the long, gently sloping hills and the broad plains and ridges. In its origin it is very similar to the yellow brown silt loam, consisting, however, of deeper soils, as it has not been disturbed by erosion to as great an extent. Much of the land here classified as medium loess was known as "prairie" or "barrens" when taken possession of by the white man, being covered by prairie grasses while the hilly type was covered with a growth of heavy timber.

Both the surface and subsoil of the medium loess vary quite widely in character because of differences in topography and drainage. Normally the surface soil is a yellowish brown silt loam. In the more flat and poorly drained places it often becomes even whitish in color and often contains iron concretions.

Observation of the country covered by the medium loess suggests that the western part is somewhat more productive than the eastern part. The country seems to improve, agriculturally, as the belt of deep loess along the Mississippi is approached. For this reason, the analyses of the medium loess soils have been tabulated in two divisions, western and eastern, the dividing line being assumed as running north and south thru Mayfield.

TABLE 3.—Plant Food Content of Medium Loess Soils (Western Part). Pounds to the Acre or in 2,000,000 Lbs. of Surface Soil (26 Samples).

	Average	Maximum	Minimum
Total nitrogen (N)	1,802	3,960	1,180
Total phosphorus (P)	1,034	1,620	682
Total potassium (K)	32,339	38,014	25,600
Phosphorus dissolved by weak acid (0.1n HNO_3), considered available	30	90	16
Potassium, same	193	590*	110
Calcium, same	1,664	2,480	1,040
Acidity, calculated as lime (CaO)	118	1,608*	10

*Not included in the average.

Pounds to the Acre or in 4,000,000 Lbs. of Subsoil (11 Samples).

	Average	Maximum	Minimum
Total nitrogen (N)	2,048	2,720	1,440
Total phosphorus (P)	2,051	3,320	1,260
Total potassium (K)	65,018	72,000	53,600
Phosphorus dissolved by weak acid (0.1n HNO_3), considered available	53	76	36
Potassium, same	353	488	288
Calcium, same	2,942	5,360	1,160
Acidity, calculated as lime (CaO)	2,300	7,080	Neutral

TABLE 4.—Plant Food Content of Medium Loess Soils (Eastern Part). Pounds to the Acre or in 2,000,000 Lbs. of Surface Soil (19 Samples).

	Average	Maximum	Minimum
Total nitrogen (N)	1,714	2,400	1,140
Total phosphorus (P)	997	1,600	670
Total potassium (K)	28,600	35,600	22,600
Phosphorus dissolved by weak acid (0.1n HNO_3), considered available	25	34	18
Potassium, same	243	424	144
Calcium, same	1,728	3,080	1,160
Acidity, calculated as lime (CaO)	157	1,240*	Neutral

Pounds to the Acre or in 4,000,000 Lbs. of Subsoil (8 Samples).

	Average	Maximum	Minimum
Total nitrogen (N)	2,430	3,920	1,200
Total phosphorus (P)	1,816	2,280	1,360
Total potassium (K)	55,500	75,400	48,400
Phosphorus dissolved by weak acid (0.1n HNO_3), considered available	44	56	28
Potassium, same	217	596*	212
Calcium, same	2,675	3,840	2,000
Acidity, calculated as lime (CaO)	4,622	8,332	80

*Not included in the average.

Inspection of the tables shows that the soil of the western part contained a little more total phosphorus, easily soluble phosphorus and total potassium than that of the eastern part and the acidity is somewhat less in the western part than in the eastern.

The easily soluble potassium is somewhat smaller than in the deep loess and river first bottoms. It is ample, however, if proper attention is given to crop rotation and the use of legumes and cover crops, crop residues and manure, with exceptions previously noted for special crops.

The nitrogen content of all upland soils of the region of medium loess is low, as also is the calcium content. The content of nitrogen may be increased economically by the growing and use of legumes, but lime and phosphate fertilizers will be necessary for a satisfactory improvement.

THE LARGE-RIVER FIRST BOTTOM SOILS

There are approximately 200 square miles of first bottom soils along the Mississippi, Ohio and Tennessee Rivers in the Purchase Region. More than four-fifths of this is found along the Mississippi and Ohio Rivers. The bottoms along the Mississippi and the Ohio to some 15 miles north of Cairo, vary in width from a mile to approximately 10 miles, there being a few places where the Mississippi River comes very close to the upland. Those points are in the vicinity of the towns of Hickman, Columbus and Wickliffe. The widest bottoms are south of Hickman, in Fulton County and north of Wickliffe, in Ballard County, above the mouth of the Ohio River. The first bottom along the Ohio River from the mouth of the Tennessee River to some three miles below where the McCracken-Ballard County line comes to the river, is at the widest part not more than three-fourths of a mile in width. The first bottom along the Tennessee River, in Marshall and Calloway Counties, is very narrow, being at very few places more than one-fourth of a mile wide.

Practically every variety of soil from coarse sand to the heaviest clays is found along the Mississippi River. The good

soils occur, as a rule, in a belt adjacent to the river occupying approximately one-half of the bottom. The heavy, poorly drained soils with the many sloughs and bayous interspersed occur, as a rule, in that portion of the bottom near the bluffs or uplands. This part of the bottom usually is considerably lower than that nearer the river channel.

The territory west of Hickman, comprising about 40 square miles, is very fertile, level land on which cotton, corn, wheat, alfalfa and various other legume crops are grown. Much alfalfa hay is shipped from this locality. Some alfalfa and sweet clover are grown on the first bottom along the Ohio River below Paducah but corn is the chief crop. Practically all the first bottom land along the Tennessee River is devoted to the growing of corn.

TABLE 5.—Plant Food Content of Large-River First Bottoms. Pounds to the Acre or in 2,000,000 Lbs. of Surface Soil (7 Samples).

	Average	Maximum	Minimum
Total nitrogen (N)	2,814	4,440	1,560
Total phosphorus (P)	2,284	3,100	1,200
Total potassium (K)	33,457	41,400	18,000
Phosphorus dissolved by weak acid (0.1n HNO_3), considered available	311	548	112
Potassium, same	340	518	210
Calcium, same	9,760	18,160	2,200
Acidity, calculated as lime (CaO)	Neutral	40	Alkaline

Pounds to the Acre or in 4,000,000 Lbs. of Subsoil (One Sample).

	Average	Maximum	Minimum
Total nitrogen (N)	2,520		
Total phosphorus (P)	3,760		
Total potassium (K)	55,200		
Phosphorus dissolved by weak acid (0.1n HNO_3), considered available	72		
Potassium, same	232		
Calcium, same	3,040		
Acidity, calculated as lime (CaO)	11,680		

Reference to table 5 above shows that the soils of the first bottoms along the large rivers are quite well supplied with phosphorus, nitrogen, potassium and calcium and usually are quite fertile. This is largely due to the yearly overflow which deposits clay, silt and fine sand. The surface soils usually are alkaline or neutral in reaction, a few being slightly acid. The one subsoil analyzed shows an unusually large acidity; this may be abnormal. The main problem in maintaining fertility is to increase the nitrogen supply by the use of legumes in the rotation and the use of cover crops.

THE LARGE-RIVER SECOND BOTTOM OR TERRACE SOILS

Terrace or second bottom soils occur along the Ohio and Tennessee Rivers and along Clark's River to a point some ten miles south of its mouth. No true second bottom, or terrace, soil is found along the Mississippi, and none along the Ohio south of the mouth of Humphrey's Creek, in Ballard County. The total area of second bottom soils in the Purchase Region probably would amount to about 100 square miles. The width of the second bottom lands ranges from ¼ mile to 1½ miles along the Tennessee River and from half a mile to three or four miles along the Ohio and along Clark's River below the junction of the East and West Forks.

The soils of the second bottom vary a great deal, ranging from the poor, white "crawfishy" flats to sands, sandy loams, loams and silt loams of fair productivity. The poor, white "crawfishy" flats constitute a large area adjacent to Paducah on the east and south. This land is very poorly drained and unproductive in the natural state. It supports a growth of scrub oak. More or less land of a similar character is found around Little Cypress and along the Illinois Central Railroad, in Marshall County. A gray silty type of land of much better quality is found practically all along the Tennessee River, in Marshall and Calloway Counties, in the second bottom. Some of the poor flat soil is also found west of Paducah in the second bottoms. There is considerable terrace or second bottom land west of Paducah that is made up of gravel loams that are devoted to general and truck farming.

TABLE 6.—Plant Food in Large-River Second Bottoms, or Terrace Soils. Pounds to the Acre or in 2,000,000 Lbs. of Surface Soil.
(4 Samples.)

	Average	Maximum	Minimum
Total nitrogen (N)	1,868	2,170	1,620
Total phosphorus (P)	1,220	1,370	1,082
Total potassium (K)	28,750	30,200	27,800
Phosphorus dissolved by weak acid (0.1n HNO_3), considered available	29	30	28
Potassium, same	236	356	160
Calcium, same	1,735	2,100	1,520
Acidity, calculated as lime (CaO)	91	3,800*	20

*Not included in the average.

Pounds to the Acre or in 4,000,000 Lbs. of Subsoil.
(2 Samples.)

	Average	Maximum	Minimum
Total nitrogen (N)	1,860	2,080	1,640
Total phosphorus (P)	2,410	2,720	2,100
Total potassium (K)	62,600	65,600	59,600
Phosphorus dissolved by weak acid (0.1n HNO_3), considered available	58	68	48
Potassium, same	390	500	280
Calcium, same	2,280	2,400	2,160
Acidity, calculated as lime (CaO)	4,220	5,240	3,200

The second bottom and terrace soils are very much poorer than the first bottom soils and in plant food content are about like the upland soils of the region, but as a rule are very much more acid and less productive. This is, of course, due in a large part to poor drainage. The total nitrogen, easily soluble phosphorus and calcium are all low.

Drainage, where needed, and growing legumes with the aid of limestone and phosphate fertilizers would greatly increase the productivity of these soils.

CREEK BOTTOM SOILS

There is hardly a section (square mile) in the upland area within the Purchase Region that does not contain more or less creek bottom land. These bottoms are found along all the streams and often extend in narrow strips even into the small ravines. They spread out and become wide at only a few miles distance from the heads of the streams. From Sedalia, some six miles from its source, to its mouth, some 35 miles, Mayfield Creek bottom, for instance, averages at least 1¼ miles in width. The soil survey of Graves County shows that creek bottoms constitute more than 20 per cent of the county. This ratio probably will hold for the entire Purchase Region.

These bottom lands lie rather flat and are naturally very poorly drained, especially in the valleys and creek bottoms. While the streams in places have cut down thru the Quarternary sands and gravels and generally are bedded in the Tertiary formation, the soils covering the valleys and bottoms have been in the main derived from the adjoining upland. Of course along the streams in the more dissected areas where the Loessal deposits have been removed by erosion and the underlying Quaternary and Tertiary formations have become exposed, the bottom soils have been more or less modified by materials derived from these formations. This, together with modifications due to drainage and to the recent erosion of the upland soils and a subsequent deposit of the materials along the shore of the bottoms and in other places along the streams, has resulted in rather varied soils in these bottoms. These variations are so local that it would be difficult and would require considerable time to separate them into distinct types.

The normal soil found in the bottoms is a light brown silt loam. In places in the wider bottoms where the soils have been subjected to poor drainage and much of the time were covered with standing water, whitish, crawfishy soils are found which contain iron concretions and iron stains. The normal subsoil is a yellowish or grayish silty material, while the subsoil of the crawfishy land is a whitish, rather compact, silty material, also containing iron stains and iron concretions. Where the Quater-

nary sands and gravels have been carried in, the soil is sandy and gravelly. In places in the wider bottoms, as in Clark's River and the Mayfield Creek bottoms, the soils are much more loamy in character. Such soils are underlaid with a yellowish loam or clay loam subsoil.

TABLE 7.—Plant Food in Creek and Small Stream Bottoms. Pounds to the Acre or in 2,000,000 Lbs. of Surface Soil (9 Samples).

	Average	Maximum	Minimum
Total nitrogen (N)	1,934	2,720	1,280
Total phosphorus (P)	1,226	1,500	570
Total potassium (K)	29,822	34,200	22,800
Phosphorus dissolved by weak acid (0.1n HNO_3), considered available	40	68	26
Potassium, same	215	388	148
Calcium, same	1,774	2,520	1,060
Acidity, calculated as lime (CaO)	290	640	10

Pounds to the Acre or in 4,000,000 Pounds of Subsoil (6 Samples).

	Average	Maximum	Minimum
Total nitrogen (N)	2,693	3,520	1,920
Total phosphorus (P)	2,057	2,780	1,040
Total potassium (K)	55,866	63,600	46,800
Phosphorus dissolved by weak acid (0.1n HNO_3), considered available	64	104	40
Potassium, same	327	412	236
Calcium, same	2,700	4,800	1,680
Acidity, calculated as lime (CaO)	1,564	2,560	40

The soils of the creek bottoms, as stated above, are quite varied in character. The plant food content is somewhat larger than in the upland soils. They are, however, more acid than the upland soils due, in many instances, to poor drainage.

With drainage systems constructed where needed, the use of limestone and phosphate fertilizers, and the growing and use of legumes, the productivity of these soils may be greatly increased.

Results from Soil Experiment Fields in the Purchase Region

(From Bulletin No. 272)

There are two soil experiment fields in the Purchase Region conducted by the Kentucky Agricultural Experiment Station. One is located at Lone Oak in McCracken County about four miles southwest of Paducah and represents the originally wooded uplands of the region. The other field is located about two miles southwest of Mayfield and represents what was originally called the "barrens" area, that is, an untimbered area.

THE LONE OAK EXPERIMENT FIELD

Work was begun on this field in 1913, altho the rotation was not fully established until 1915. The rotation was temporarily suspended at the end of 1923 in order to try methods of eliminating wild onions with which the field was badly infested and which the rotation and cultivation methods used did not eradicate. Corn yields were obtained by plots in 1924 and 1925.

The rotation used was corn, soybeans, wheat and clover. Limestone and fertilizers were used as follows: Where limestone has been used it has been applied at the rate of two tons per acre once in a rotation period for two rounds of the rotation, after which its use was discontinued. Acid phosphate was used at the rate of 800 pounds per acre and rock phosphate at the rate of 1,600 pounds per acre for a rotation period, for two rounds of the rotation, after which these materials were used in half of these quantities. Muriate of potash or its equivalent has been used at the rate of 200 pounds per acre per rotation, except for the one application of 400 pounds per acre in the first round of the rotation. Where nitrate of soda was used 100 pounds per acre was used on corn and 100 pounds per acre as a top dressing on wheat.

Limestone and the fertilizers (except nitrate of soda) have been applied when the ground was prepared for corn. The rock phosphate is plowed under and the other materials are disked in on the broken ground.

Manure was used on all plots of the corn ground, except No. 1 and No. 11, at the rate of 6 tons per acre for one round of the rotation, from 1916 to 1919. After this time the cornstalks and wheat straw were returned on all plots except No. 1 and No. 11. From 1916 to 1919 the cornstalks and wheat straw were returned to plot No. 11. The second crop of clover was left on the ground.

The soybean crop of 1915 was harvested for seed. The soybean hay crop of 1920 was lost because of continued rains. Clover was a failure in 1923 on account of drouth in 1922. The crop yields on this field and the treatments used are given in table 8.

TABLE 8.—Average Crop Yields Per Acre. Lone Oak Soil Experiment Field.

Serial Plot No.	Treatment*	Corn Ave. 13 Crops	Soybean Hay, Lbs. Ave. 9 Crops	Wheat, Bus. Ave. 10 Crops	Clover Hay, Lbs. Ave. 7 Crops	Crop Increases**				
						Treatment Producing the Increase	Corn	Soybean Hay	Wheat	Clover
1	O	28.4	2011	7.6	903	....	.....	.....	.....	.....
2	ML	36.2	2591	10.8	2091	L	5.2	327	0.7	884
3	M	31.0	2264	10.1	1207	M	2.6	253	2.5	304
4	MAP	33.3	2504	11.6	1563	AP	.8	104	1.4	177
5	MAPK	35.9	2761	11.7	2151	APK	2.0	225	1.5	586
6	MRP	35.4	2735	12.5	2303	RP	.1	63	2.2	559
7-8	M	36.8	2809	10.3	1924	....	.....	.....	.....	.....
9	MLAP	41.3	3503	18.2	3584	LAP	4.9	798	7.4	1656
10	MLRP	43.8	3507	17.9	3389	LRP	7.9	707	6.6	1457
11	LAP	42.1	3473	19.5	3913	LAP	6.6	678	7.7	1977
12	M	35.1	2790	12.2	1939	....	.....	.....	.....	.....
13	MK	36.2	2792	12.7	1954	K	1.6	48	.4	22
14	MLK	38.7	3192	15.8	2944	LK	4.5	439	3.5	1020
15	MLAPK	40.6	3442	19.5	3727	LAPK	6.9	788	7.1	1810
16	M	33.2	2609	12.4	1909	....	.....	.....	.....	.....
17	MLRPK	43.1	3292	16.2	3364	LRPK	9.9	683	3.8	1455
18	MLAPKN	40.9	3408	19.7	3664	LAPKN	7.7	799	7.3	1755

* O = No treatment; M = manure and crop residues; L = limestone; AP = acid phosphate; RP = rock phosphate; K = potash; N = nitrate of soda.

**The crop increases attributed to limestone and the various fertilizers are the increases above any increase produced by the manure and crop residues used. Increases are calculated by assuming a uniform variation of soil between check plots.

A discussion of these results will be found in connection with the Mayfield results (page 29) which are similar to those.

THE MAYFIELD EXPERIMENT FIELD

Work was begun on this field in 1913. A four-year rotation of corn, soybeans, wheat and clover is used on part of this field. (Winter oats occupied the place of soybeans for the first three years.)

Fertilizer and limestone have been used in this rotation as follows: Where limestone has been used it has been applied at the rate of two tons per acre once in a rotation period, for two rounds of the rotation, after which its use was discontinued. Acid phosphate was used at the rate of 800 pounds per acre and rock phosphate at the rate of 1,600 pounds per acre for a rotation period, for two rounds of the rotation, after which these materials were used in half of these quantities. Muriate of potash or its equivalent has been used at the rate of 200 pounds per acre per rotation, except for the one application of 400 pounds per acre in the first round of the rotation. Where nitrate of soda was used 100 pounds per acre was used on corn and 100 pounds per acre as a top dressing on wheat.

Limestone and the fertilizers (except nitrate of soda) have been applied when the ground was prepared for corn. The rock phosphate is plowed under and the other materials are disked in on the broken ground. The fertilizer applications are being shifted to the wheat land but this change does not affect the re-results reported in this bulletin.

Manure was used on all plots on the corn ground except plots No. 1 and No. 10 at the rate of 6 tons per acre for one round of the rotation, from 1916 to 1919. After this, manure was used on the corn plots except 1 and 10 at a rate equal to the weight of the crops removed from the four corresponding plots in the previous rotation. The second crop of clover is left on the ground. From 1916 to 1919 plot 10 had the cornstalks and wheat straw returned to it. Since then no manure or residues have been returned.

The corn crop of 1919 was destroyed for experimental purposes by cattle breaking into the field. Soybeans were not introduced into the rotation until 1916, winter oats occupying their place previous to this time. There was no wheat crop in 1920

on account of a wet season preventing the sowing of wheat. The clover crop of 1923 was a failure on account of drouth in 1922.

The crop yields obtained on this field and the treatments used are given in table 9.

TABLE 9.—Average Crop Yields Per Acre, Four-Year Rotation, Mayfield Soil Experiment Field.

Serial Plot No.	Treatment*	Corn, Bus. Ave. 12 Crops	Soybean Hay, Lbs. Ave. 10 Crops	Wheat, Bus. Ave. 11 Crops	Clover Hay, Lbs. Ave. 9 Crops	Crop Increases**				
						Treatment	Corn	Soybean Hay	Wheat	Clover Hay
1	O	23.7	1822	4.6	381	O	.....	.....	.....	.....
2	ML	36.9	3051	10.4	2314	L	8.2	837	4.1	1767
3	M	28.7	2214	6.3	547	....	5.0	392	1.7	166
4	MAP	30.3	2573	8.9	767	AP	.7	299	2.2	177
5	MRP	34.2	2868	9.7	1625	RP	3.8	535	2.7	632
6	MLAP	44.4	3608	16.5	3349	LAP	13.1	1215	9.2	2674
7	M	32.2	2452	7.7	717	....	.....	.....	.....	.....
8	MLRP	44.5	3619	17.3	3201	LRP	12.2	1108	9.6	2409
9	MLAP	40.4	3598	18.0	3393	LAP	8.0	1028	10.2	2526
10	LAP	36.8	3496	15.1	3148	LAP	4.2	867	7.3	2207
11	M	32.7	2688	7.8	1016	....	.....	.....	.....	.....
12	MK	33.5	2780	9.5	978	K	0.0	44	1.6	—132
13	MLK	44.2	3889	15.8	3053	LK	10.0	1105	7.8	1849
14	MLAPK	47.6	4149	20.5	4129	LAPK	12.6	1316	12.5	2831
15	M	35.7	2881	8.1	1392	....	.....	.....	.....	.....
16	MLRPK	45.3	3950	13.7	3701	LRPK	9.6	1069	5.6	2309
17	MLAPKN	42.7	3918	18.8	3839	LAPKN	7.0	1037	10.7	2447

* O = No treatment; M = manure; L = limestone; AP = acid phosphate; RP = rock phosphate, K = potash; N = nitrate of soda.

**The crop increases attributed to limestone and the various fertilizers are the increases above any increase produced by the manure used. Increases are calculated by assuming a uniform variation of soil between check plots.

TOBACCO ROTATIONS

Several tobacco rotations are conducted on this field. Where limestone has been used it has been applied at the rate of two tons per acre when the ground was prepared for tobacco. This was done for two rounds of the rotation, after which its use was discontinued. Acid phosphate was used at the rate of 600 pounds per acre per rotation and sulfate of potash at the rate of 150 pounds per acre per rotation, both materials being applied in

the full amount on the tobacco ground. After two rounds of the rotation acid phosphate was reduced to 300 lbs per acre. Nitrate of soda was used at the rate of 100 pounds per acre each on tobacco and wheat except that in 1924 and 1925 it was used at the rate of 200 pounds per acre on tobacco.

The crop yields obtained in these rotations and the treatments used are given in Table 10.

TABLE 10.—Average Crop Yields in the Tobacco Rotations. Mayfield Soil Experiment Field.

Serial Plot No.	Treatment*	Tobacco, Lbs. Ave. 9 Crops	Wheat, Bus. Ave. 11 Crops	Wheat, Bus. Ave. 5 Crops	Hay, Lbs. Ave. 9 Crops	Hay, Lbs. Ave. 6 Crops	Crop Increases		
							Tobacco 9 Crops	Wheat Last 5 Crops	Hay, 9 Crops
1	AP	820	14.2	12.6	1602	.....	196	8.8	616
2	LAP	942	22.7	22.2	3738	.....	318	18.4	2752
3	O	624	6.6	3.8	986	.....	.....	.....	.....
4	LAPK	926	18.5	17.5	3330	.....	302	13.7	2344
5	LAPKN	1070	22.1	21.2	4078	.....	446	17.4	3092
6	LAPN	997	.....	22.2	4071	.....	373	18.4	3085
7	AP	798	.....	15.2	.....	2252	174	11.4	.....
8	LAP	942	.....	22.8	4555	4264	318	19.0	.....
9	AP	1028	.....	16.3	2322	2327	404	12.5	.....

* AP = Acid phosphate; L = limestone; K = potash; N = nitrate of soda.

The rotation on plots 1 and 6 is tobacco, wheat, clover

The rotation on plot 7 is tobacco, wheat, mixture of orchard grass and Japan clover. The rotation on plot 8 is tobacco, wheat, sweet clover. The rotation on plot 9 is tobacco, wheat and Japan clover. On plot 6 winter oats was used for a while instead of wheat. On plots 7, 8 and 9 rye was used instead of wheat until the last five years, the rye being clipped when jointed and left on the ground to represent pasturing. On plot 7 orchard grass only was cut for a while. It has never made a satisfactory growth, so it is not cut now, but Japan clover is cut in the fall. This has been done for the last 6 years.

Japan clover is seeded on the wheat on frozen ground in March, and reseeds itself in the fall, usually giving a very heavy stand the next year when it is cut for hay. One year it failed to

reseed sufficiently to make a crop and one year it was too short to cut on account of drouth. An average of the actual crops on plot 9 was 2,613 pounds per acre. The highest yield was 5,690 pounds per acre and the lowest, 1,256 pounds.

It is significant that the yield of tobacco in the Japan clover rotation is only 42 pounds less than in the best fertilizer treatment in the tobacco-wheat-red clover rotation. Where lime cannot be used a great deal of improvement can be made by using a phosphate fertilizer and growing Japan clover in the rotation. If Japan clover were fertilized with a phosphate, it would make a good hay crop on many soils where it does not get high enough to cut when not fertilized.

The soils of the Lone Oak and Mayfield fields are very similar and the results on the two soil experiment fields are quite similar. The outstanding requirements for improving these soils are the use of lime and phosphate, the use of legumes in the rotation, and the return of manure or the plowing under of the legumes.

The returns from phosphate without limestone have been very poor on both fields. The returns from limestone alone have been poor on the Lone Oak field, but better than from phosphate alone. The returns from limestone alone have been fair at Mayfield. The returns from limestone and phosphate used together have been profitable on both fields but much better at Mayfield, due in a large measure, no doubt, to the larger use of manure in the four-year rotation on this field. Worn soils cannot be brought to a high state of productiveness without either turning under legume crops or returning manure made from feeding legumes along with other crops.

Rock phosphate has been more effective on unlimed soil than acid phosphate, while on limed soil it has been about as effective as acid phosphate.

Tobacco has been increased more than enough (128 pounds per acre) by the use of nitrogen and potash to pay for their use at fair prices for tobacco. No manure was used in the tobacco rotation and no legumes were turned under except what growth the clovers made the year they were seeded and the second growth after harvesting.

The results of the Lone Oak and Mayfield experiment fields are applicable to the region west of the Tennessee River with the exception of the fertile bottoms of the Ohio and Mississippi Rivers.

For suggestions for fertilizing tobacco, see page 37.

FERTILIZER TESTS ON COTTON

On the Mayfield experiment field there are five series of plots, similarly treated. On these is run a four-year rotation of corn, soybeans, wheat and clover. The first and fifth series were planted to the same crop each year.

In 1924 one of these duplicate series was withdrawn from the rotation and used for fertilizer tests on cotton. This series had had three rounds of the rotation, named above, and had therefore had two applications of limestone on the limed plots and three applications of fertilizers on the variously fertilized plots, according to the rates and manner of application named on page 34. All plots except No. 1 and No. 10 had had applications of manure in 1917 and 1921. This series was in clover that would have been harvested in 1924, but the spring growth was turned under in preparation for cotton April 15, when there was a good growth of clover on plots that had lime and phosphate on them.

No additional lime was applied for the cotton in 1924. The various fertilizers were used as follows:

Acid phosphate	200 lbs. per acre
Rock phosphate	400 lbs. per acre
Muriate of potash	100 lbs. per acre
Nitrate of soda	100 lbs. per acre (plot 17)

All fertilizers were applied broadcast except nitrate of soda, which was applied along the sides of the rows after the cotton was thinned.

In 1925 the series of plots, which were tenth acres, was divided into two series of twentieth acre plots to be used in a rotation of cotton and cowpeas, with a rye cover crop each winter.

In 1925 no additional fertilizers were used except nitrate of soda on plots 9 and 17 at the rate of 200 lbs. per acre along the sides of the row after the cotton was thinned.

The yields of cotton are given in Table 11.

TABLE 11.—Yields of Cotton in Fertilizer Tests. Mayfield Soil Experiment Field.

Serial Plot No.	Treatment*	Yield Per Acre of Seed Cotton			
		1924 Lbs.	1925 Lbs.	Ave. Lbs.	Increase Lbs.
1	O	205	148	177	.....
2	ML	480	232	356	10
3	M	470	222	346	74
4	MAP	480	528	504	165
5	MRP	555	696	626	293
6	MLAP	430	549	490	164
7	M	480	158	319	.....
8	MLRP	650	306	478	126
9	MLAP†	725	390	558	173
10	LAP	740	633	687	270
11	M	605	295	450	.....
12	MK	740	232	486	9
13	MLK	1130	380	755	251
14	MLAPK	1485	760	1123	594
15	M	795	317	556	.....
16	MLRPK	1320	506	913	357
17	MLAPKN	1485	549	1017	461

* O = No treatment; M = manure; L = limestone; AP = acid phosphate; K = potash; N = nitrate of soda.

†Plot No. 9 had 200 lbs. of nitrate of soda per acre in 1925, but none in 1924.

In 1924 the season was very favorable for cotton. A good stand was obtained, the plants made excellent growth and fruited well thruout the summer. The crop opened and was saved with good weather. The reverse condition was true in 1925. The cotton came up poorly because of a drouth following planting and tho a stand finally came thru, the later plants never matured properly. On plots 4 and 5 which are on lower ground where moisture conditions were more favorable, a very good stand of cotton was secured immediately and for that reason the cotton matured and opened earlier than elsewhere. The long drouth during the latter part of the summer prevented full development and also caused the crop to open up before reaching maturity. Rains setting in just after the first picking was made prevented the other pickings from being made; therefore the results for 1925 are not complete.

In 1925 a fertilizer test of cotton was conducted on a series of plots at Lone Oak that had been handled in exactly the same way as the soils at Mayfield up to the fall of 1924, except that this series had had only one application of manure but had the corn stalks and wheat straw returned in 1921. In the fall of 1923 this series, then in young clover, was plowed up and was seeded to soybeans in 1924, followed by a cover crop of wheat. In 1925 the series was broken and the various fertilizers were applied as follows:

Acid phosphate	400 lbs. per acre
Rock phosphate	800 lbs. per acre
Muriate of potash	200 lbs. per acre
Nitrate of soda	200 lbs. per acre

All fertilizers were applied broadcast except nitrate of soda which was applied along the cotton rows after thinning.

The yields of cotton are given in Table 12.

TABLE 12.—Yields of Cotton in Fertilizer Tests. Lone Oak Soil Experiment Field.

Serial Plot No.	Treatment*	Yields Per Acre, Seed Cotton, Lbs.	Increase†	Per Cent Secured at First Picking
1	O	450	115	48.9
2	LM	485	150	51.6
3	M	335	.....	43.0
4	APM	705	336	68.1
5	APKM	765	362	62.8
6	RPM	635	199	71.7
7	M	470	.....	64.9
8	M	435	.....	57.5
9	LAPNM	565	143	67.3
10	LRPM	490	79	61.2
11	LAP	500	102	68.0
12	M	385	.....	52.0
13	KM	400	5	50.0
14	LKM	410	15	53.7
15	LAPKM	625	180	71.2
16	M	465	.....	59.1
17	LRPK	575	110	59.1
18	LAPKN	680	215	63.1

*O = No treatment; M = manure and crop residues; L = limestone; AP = acid phosphate; RP = rock phosphate; K = potash; N = nitrate of soda.

†The crop increases attributed to limestone and the various fertilizers are the increases above any increase produced by the manure and crop residues used. The increases are calculated by assuming a uniform variation of soil between check plots.

The year 1925 was very unfavorable for cotton as was explained in connection with the experiments at Mayfield. The same difficulty was experienced in getting a stand as at Mayfield; however, the cotton opened fairly well and both pickings were saved. The percent of seed cotton obtained at the first picking is shown for each treatment as this is indicative of earliness. The Tennessee Trice variety was used in the experiment. The average turn-out of lint from the seed cotton was over 35%.

THE USE OF LEGUMES AND MANURE

While lime and fertilizers are necessary to the growing of clovers and greatly increase the growth of cowpeas and soybeans, and other crops to some extent, soils cannot be brought to a high state of productivity without either turning under the legume crops or returning the manure made by feeding them and other crops grown.

The cropping system should have a legume crop on each field at least once in four years. In order that the legume may make the greatest improvement of the soil it should be turned under, grazed down, or fed with the return of manure made by feeding it along with other crops. Turning under the legume crop is an expensive way of improving the soil. Experiments have shown that manure made by feeding the crops grown in a rotation, such as is used on the experiment fields, is as effective as turning under the clover crop and returning all the stalks and straw of the other crops.

Some improvement in poor soils may be expected from growing clover and removing it and not returning manure made from it, but a high state of productivity cannot be reached. The use of soybeans and cowpeas in this way will not materially improve soils.

SUGGESTIONS FOR THE USE OF LIMESTONE AND PHOSPHATES

1. The more finely limestone is ground, the more effective it is. Limestone that will not pass a screen of ten meshes to the inch is of doubtful value. Screenings may be sold cheaply enough to justify buying them for the fine material in them. Usually the ¼-inch to dust stone will contain about 75 to 80

per cent of material that will pass a 10-mesh sieve. Limestone coarser than this is of doubtful economy at any price. Cases are known in which the coarse material ran as high as 47 per cent.

2. In most of the Purchase Region one ton of finely ground limestone per acre will be sufficient to produce clovers, including sweet clover. Two to four tons should be applied for alfalfa. On most soils two tons will be sufficient. One ton will not last as long as two tons, but it is better to have all of the farm limed with one ton per acre than half of it limed with two tons per acre. Reliming should be determined by whether clover is growing successfully.

3. Limestone may be spread either before or after plowing. If spread before plowing it should be disked in before plowing. It should also be disked in when spread on plowed ground. Limestone and acid phosphate may be spread at the same time and disked in together. Acid phosphate should not be applied before limestone. Acid phosphate and limestone may be mixed before spreading. Limestone and acid phosphate applied together should be disked in before rained upon. Generally it is not advisable to use rock phosphate on recently limed ground. Limestone may be spread at any time of the year. It should not be left on the surface if it will wash away.

4. For alfalfa it is well to apply limestone a year or two before sowing the crop. Experiments have proved that this produces better alfalfa. For clover, it is a good practice to spread the lime on the ground for corn or some other preceding crop. The increases of the preceding crops will often pay for the limestone, and the tillage distributes the lime better for the clover.

Limestone does not often directly benefit tobacco, but it will indirectly benefit it in a rotation in which clover is grown.

5. Limestone may be spread with a shovel if care is exercised. It is necessary to get accustomed to a "swing" of the shovel that will throw the limestone evenly in a fairly broad strip. A man standing in the rear of a wagon can cover a strip about 15 feet wide at a "sling." The shovel is swung around in a semicircle on a horizontal line and so held that the limestone

leaves it in a uniform stream. The "lick" must be learned by practice. The writer has seen two men spread two tons of limestone on an acre in this way in less than an hour.

6. Limestone may be spread with a manure spreader by observing the following rule: Set the spreader at the lowest number of loads it will spread per acre. Divide the amount of limestone desired per acre by the number of loads at which the spreader is set. This gives the weight of limestone to be used each load. Spread enough litter on the apron of the spreader to prevent the stone from sifting thru.

7. Time will be saved if the limestone can be spread from the wagon as hauled to the field. This can be done with the ordinary lime spreader by removing the tongue and putting in a stub tongue which can be hooked to the rear axle of the wagon so as to draw the spreader close up to the rear of the wagon box. A man shovels limestone into the spreader while another drives.

If an end-gate spreader is being used, an extra sprocket may be bought for each wagon in service and the spreader attached to each wagon as it is unloaded. The end-gate spreader has the advantage of spreading a wider strip than other types of spreaders.

8. On many soils that are only very slightly acid, often a small amount of limestone will be sufficient to produce clover. The following practice is recommended for trial where limestone is difficult to obtain:

Mix 2 parts of finely ground limestone or burned lime and 1 part of acid phosphate. Drill the mixture at the rate of 1,000 pounds per acre with fall-sown grain or spring-sown oats. Seed a mixture of red and alsike clover or sweet clover on the grain in the late winter or early spring. Leave a small strip unlimed in order to check on the results.

9. *Important.* A phosphate is just as necessary as limestone. In fact, in most cases limestone used without a phosphate will be disappointing.

10. In farm practice probably the most economical way to use acid phosphate is to drill about 400 pounds per acre when wheat or other small grain is sown. This will be sufficient for

the wheat and for the clover or grass crop which usually follows wheat. If this practice is followed regularly with each rotation and manure is used on the land on which corn is grown following the clover and grass, it will not be necessary to use additional phosphate, provided the manure has been saved carefully, and as much as six to eight tons per acre has been used. Additional fertilizers will probably pay on tobacco.

11. If it is desired to use acid phosphate in connection with manure for corn, tobacco or other crops, it may be applied when the manure is being spread. When loading the spreader, place a layer of manure and sprinkle over it uniformly some acid phosphate. Two layers of manure and phosphate should give an even spread of the phosphate on the land. The amount of phosphate for each load of manure is determined by dividing the application of phosphate desired per acre by the number of loads of manure to be used per acre.

12. For inter-tilled crops, such as corn, tobacco and beans planted in rows, it is best to apply the acid phosphate broadcast, or drill it with the fertilizer attachment of a grain drill. Without doubt, it is more effective applied this way than in the row, for the feeding roots have a better opportunity to come in contact with the phosphate thruout the growing season. Broadcast applications should be made on the broken ground so that the fertilizer may be thoroly distributed in the soil in the preparation of the seed bed. Where an application of as much as 600 pounds per acre is used, to last for a period of three or four years or more, the phosphate may be applied broadcast on the unbroken ground and disked in before breaking.

Only with very small amounts of acid phosphate, say 100 pounds per acre, would drilling in the row be recommended. But we do not believe it advisable to use such small applications.

13. Experiments on some of the Kentucky experiment fields indicate that it makes very little difference in yields whether large amounts of acid phosphate are applied at once for a rotation, or the same amount is divided into annual applications for the same period of time. Very little phosphate is lost by leaching.

14. Rock phosphate should not be used in small annual applications. One thousand to 1,500 pounds per acre, sufficient for three to five years, should be applied broadcast on the unbroken ground and should be disked in before breaking. It may be applied with a lime spreader, thru the fertilizing attachment of a grain drill, or when manure is being spread, in the manner already indicated for acid phosphate.

15. Contrary to much that has been written on the subject, it has been found on the Kentucky experiment fields that rock phosphate gives good results on thin land the first year before animal manure or green manure crops have been used. Of course much larger yields will be obtained by the use of manures than without them.

16. When the price of acid phosphate is twice as much per ton as rock phosphate, or more, farmers well may consider the use of rock phosphate, altho it is more bulky and troublesome to handle. The excess of phosphorus that is stored in the soil by its use is an important consideration. After using rock phosphate for two rotations at the rate above recommended, the amount may be reduced by half. Especially is this true where manure is being returned to the soil.

SUGGESTIONS FOR THE FERTILIZATION OF TOBACCO

If the soil where tobacco is to be grown is in first class condition, such as a good clover sod or land manured at the rate of 10 or 12 tons per acre, it is quite likely that liberal fertilization with acid phosphate, basic slag or steamed bone meal will be sufficient. Three hundred to five hundred pounds per acre of acid phosphate or basic slag or two hundred to three hundred pounds of steamed bone meal is a liberal application.

Unless the soil for tobacco is in a high state of productivity, such as would produce something like 75 to 80 bushels of corn per acre in a favorable season, it is highly probable that it will pay to fertilize tobacco with a complete fertilizer.

The following formula is suggested for tobacco.

Acid phosphate or basic slag.....1150 lbs.
Nitrate of soda ..... 675 lbs. or 500 lbs. sulfate of ammonia
Sulfate or muriate of potash..... 175 lbs.

2000 lbs.

Basic slag should not be mixed with sulfate of ammonia, but should be applied separately. (If sulfate of ammonia is used, the amount of acid phosphate may be increased 175 lbs. per ton of mixture.) This is approximately a 6½-9-4 formula. Very few fertilizers offered for sale in Kentucky contain enough nitrogen for tobacco where it is really needed.

If a ready-mixed fertilizer is used it is recommended that one containing not less than 4 percent each of nitrogen and potash be used. The percentage of nitrogen should be at least as high as the percentage of potash, and it is usually desirable that it should be higher, particularly on the thinner soils.

The fertilizer requirements of tobacco on soils of different degrees of fertility can usually be provided for as well by varying the amount of a good formula as by varying the formula. Any excess of phosphorus and potassium above the needs of the tobacco crop will be held in the soil and will be available to succeeding crops.

Since farmers are better able to judge of the productiveness of their soils in yields of corn than any other crop, the following suggestions are made for applications of fertilizers for tobacco:

If the soil will produce in a season of good rainfall,

30 to 40 bu. of corn per acre use 500 to 750 lbs. of fertilizer per acre
40 to 60 bu. of corn per acre use 300 to 500 lbs. of fertilizer per acre
60 to 80 bu. of corn per acre use 300 lbs. of fertilizer per acre

As much as 500 pounds of mixed fertilizer per acre may be used in the row if it is well mixed with the soil. A satisfactory practice is to use 200 pounds in the row and the remainder broadcast. With applications of more than 500 lbs. per acre it may as well all be applied broadcast.

It is strongly recommended that tobacco be grown only upon land kept in the best of condition thru the use of clovers and

grass. Tobacco of high quality can be produced only in this way. No kind of fertilization with commercial fertilizers will take the place of a soil made fertile thru the proper use of legume and manure.

The tobacco crop can often be made to pay for the fertilizers for the succeeding crops in the rotation. An additional 300 pounds of fertilizer per acre would cost, say $7.00. An increase of 70 lbs. of tobacco per acre at 10 cents per lb. would pay for the fertilizer. But 70 lbs. of tobacco would use only a small part of the 300 lbs. of fertilizer and the excess would remain in the soil for the succeeding grain and grass crops. An application of 600 lbs. of fertilizer of the grade recommended would serve this purpose.

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